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Effects of Habitat Manipulation Projects on Non-target Wildlife Species in the Williston Watershed

P. A. Giroux
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Peace/Williston Fish and Wildlife Compensation Program, 1011 Fourth Ave. 3rd Floor, Prince George B.C. V2L 3H9

Website: *www.bchydro.bc.ca/environment/initiatives/pwcp/*

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Author(s): Paul A. Giroux[1]

Address(es): [1] ECL Envirowest Consultants Ltd., 204-800 McBride Blvd., New Westminster, B.C. V3L 2B8

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1.0 INTRODUCTION

To achieve the goal of enhancement of wildlife habitats within the Williston Lake watershed, the Peace/Williston Wildlife Compensation Program (PWCP) has conducted prescribed burning habitat manipulations to benefit species that utilize early seral vegetation communities (eg. moose, elk, bears). For purposes of this contract, a work plan is presented that details an approach designed to evaluate the adverse effects of prescribed burning of mature and old aspen forests on non-target wildlife species.

1.1 Background

Prescribed burning has occurred at eight locations throughout the Williston Lake watershed; three burn sites are located in the central and two in the lower Finlay watershed; and three along the northern shore of the Peace arm of Williston Lake. Burning has been conducted in both Boreal Black and White Spruce [BWBS], and Sub-boreal Spruce [SBS] biogeoclimatic zones. However, the majority of prescribed burns have occurred on south-facing mature aspen dominated stands and have ranged in intensity (hot and cool) and size (200 - 900 ha).

The program of prescribed burning has met its requirements for habitat enhancement for target species. However, the PWCP is interested in determining the impacts of prescribed burning on non-target wildlife species in order to avoid the exclusion of one or more species in favour of another. A literature search of relevant studies was completed to isolate and rank wildlife species based on their reliance on mature or old aspen forest for a portion of, or for their entire life history.

2.0 SPECIES SELECTION AND RANKING

Species that have demonstrated a reduction in abundance or have exhibited a dependence on mature or late seral aspen forest were investigated. Numerous studies designed to determine the effects of clear-cut logging or fire on wildlife communities were examined. However, a disparity within the literature exists for studies that describe the effects of mature aspen forest manipulations on wildlife communities. This is most likely due to the historically low value associated with *Populus* forests by the logging industry, thereby providing little impetus to study the impact of its disturbance on wildlife communities.

Recently, mixed-wood forests dominated by *Populus* species have come under pressure by logging companies who now find it economically viable to harvest aspen forest for pulp wood (Nikiforuk and Struzik 1989). The resultant loss of mixed boreal forest has motivated researchers to study the impacts associated with forest disturbance on natural wildlife communities. The majority of the research has been conducted in central Alberta and has

focused on avian communities (Anonymous 1994, Schmiegelow 1995, Westworth and Telfer 1993) with the exception of one, which included mammals in their investigation (Anonymous).

In B.C., Darling and Farr (1994) have completed two seasons of pre-treatment wildlife community data collection in aspen dominated forests in the Dawson Creek Forest District (Forest District - 47). One of their study sites was however, exposed to clear-cut logging during the 1992/93 winter season. The results of this sampling represents a single year of post-treatment data from one site, therefore, the results can only be considered preliminary. Once completed, the results of their research will provide relevant information on the short-term impacts (< 2 yrs) of aspen forest disturbance on wildlife communities in northeastern B.C. Campbell et al. (1990) have compiled breeding bird activity and locations within B.C., but, do not provide quantitative comparisons of habitat use by individual species.

Wildlife species known or suspected to occur in the Williston lake watershed, and that had demonstrated a negative response to forest disturbance by others, were ranked based on the results presented in the literature. Species were then classified as being at high risk, moderate or low risk of incurring a reduction in population as a result of the prescribed burning program currently under operation in the PWCP area. Results of the literature evaluation are presented below and summarized in Table 1.

Table 1: Ranking of avian species likely to decline in population following disturbance of mature aspen forest. (Based on: Anonymous, Darling and Farr 1994, Schmiegelow 1995, Westworth and Telfer 1993, Murray 1993, Campbell et al. 1990, Thompson and Capen 1988)

High	Moderate	Low
Yellow-bellied sapsucker	Pileated woodpecker	Ovenbird
	Yellow-rumped warbler	Magnolia warbler
	Black-throated green warbler	Northern flicker
	Mourning warbler	Downy woodpecker
	American redstart	Hairy woodpecker
	White-breasted nuthatch	Least flycatcher
	Philadelphia vireo	Rose Breasted grosbeak
	Warbling vireo	
	Red-eyed vireo	
	Canada warbler	

High = species most likely to decline in population with the loss of mature and old aspen forest;
Moderate = species likely to decline in population with the loss of mature and old aspen forest;
Low = species that may decline with the removal of mature and old aspen forest.
Underline = blue listed species (vulnerable; B.C. Environment 1991)

2.1 High Sensitivity Species

The yellow-bellied sapsucker *(Sphyrapicus varius)* has been isolated as the species most likely to suffer negative effects as a result of the prescribed burning of mature trembling aspen forest in the PWCP area.

Murray (1993) reported a high density of yellow-bellied sapsuckers (n=25) nesting in live trembling aspen *(Populus tremuloides)* in comparison to other cavity nesters encountered (n = 3) in the Dawson Creek Forest District. Murray also indicated that large live aspens ($\bar{x}$ dbh 29.6 cm) with heart rot, were the primary nest sites. Murray's observations concur with notes collected by others (eg. Campbell *et al.* 1990, Keisker 1987, Kilham 1971, Lawrence 1967, Bent 1939 and Philipp and Bowdish 1917) who all noted a preference of S. *varius* for large, live trembling aspens. Campbell et al. (1990) noted that over 80% of all occurrences of *S. varius* nesting in B.C. occurred in trembling aspen. Other tree species used were either balsam popular *(Populus balsamifera)* or white birch *(Betula papyifera).*

Westworth and Telfer (1993) quantified breeding densities of avian communities in five different age classes of mixed-aspen forest in central Alberta. In their study, it was shown that breeding pairs of *S. varius* were limited to the 80 year-old aspen forest age class (Westworth and Telfer 1993). Darling and Farr (1994) reported 88 sightings of *S. varius* in undisturbed aspen forested areas during the 1993/94 field season and one incidental sighting of 5. *varius* in the one clear-cut study area.

Thompson and Capen (1988) described avian communities in seral stages for a Vermont forest and demonstrated a preference of *S. varius* for forests dominated by deciduous trees. Of the five plots where 5. *varius* was observed, deciduous basal area was 16.5 m^2, compared to 1.0 m^2 of coniferous basal area (Thompson and Capen 1988). In their Principal Components Analysis (PCA), *S. varius* fell on the PC1 axis closest to undisturbed, deciduous dominated forest (Thompson and Capen 1988).

Keisker (1987) located 159 *S. varius* nest sites in her 2040 ha study area near Orchard Lake, B.C. Her analysis demonstrated that 5. *varius* exhibited a significant preference for live aspen trees over 25 cm dbh, with visible fungal conks and scars present. She also noted that *S. varius* nested in forest groves or stands dominated by deciduous trees, primarily trembling aspen *(P. tremuloides)* and white birch *(Betula papyrifera).* The remainder of the forest in her study area was dominated by Douglas fir *(Pseudotsuga menziesii).*

In her study of canopy utilization by avian species in unlogged and logged forest in Arizona, Franzreb (1983) discovered that *S. varius* increased in breeding abundance after selective logging of coniferous trees had occurred and trembling aspen were left. She also demonstrated that trees over 21 m in height were preferred, with 30 m being the mean tree height used by *S. varius.*

Studies completed by the Alberta Ministry of Environment, Wildlife Ecology Branch, demonstrated the greatest occurrence of *S. varius* in old aspen forest (> 80 yrs); whereas, young stands (20-30 yrs old) and mature stands (40 - 60 yrs) had significantly fewer *S. varius*. However, their results indicated that *S. varius* were more likely ($p < 0.01$) to be observed in young stands than in mature stands. Since this study provided a record of occurrence and not breeding activity, it is not clear whether *S. varius* were foraging or nesting in the young stands.

The combination of the evidence presented above illustrates, with a relatively high degree of clarity, that *S. varius* exhibits a reliance on older aspen forest for breeding and deciduous dominated forests for foraging. Furthermore, destruction of large live trees in old and mature aspen forest would most likely result in a decline in their population in the Williston Lake watershed.

2.2 Moderate and Low Sensitivity Species

2.2.1 Avifauna

Avian species were divided between moderate and low sensitivity categories based on the degree of their response to the following criteria: (1) species that have demonstrated greater abundances in old and mature aspen forests compared to young or recently disturbed forests but, were not shown to have specific habitat requirements limited to old and mature aspen forests; (2) demonstrated a clear preference for deciduous (aspen) forest as opposed to coniferous for a critical portion of their life history (breeding or foraging); (3) species considered endangered (red listed) or vulnerable (blue listed) within B.C.; or (4) have demonstrated a strong response in one or more studies but not in others were classified as being at moderate to low risk of incurring a population decline as a result of the prescribed aspen forest burning program.

Yellow-rumped warbler *(Dendroica coronata)*, black-throated green warbler *(Dendroica virens)*, mourning warbler *(Oporornis philadelphia)*, American redstart *(Setophaga ruticilla)* and chipping sparrow *(Spizella passerina)* all demonstrated greater breeding densities in forest age classes older than 60 years (Westworth and Telfer 1993). Thompson and Capen (1988) were able to show that American redstart, Ovenbird *(Seiurus aurocapillus)* and red-eyed vireo *(Vireo olivaceus)* had an affinity for undisturbed deciduous forest, whereas, hairy woodpecker and black-throated green warbler were correlated with undisturbed mixed deciduous forest.

Comparing avian abundance between young and old aspen forests near Calling Lake, Alberta, Schmiegelow (1995) discovered yellow-rumped warbler, mourning warbler and Ovenbird were absent in young forest areas whereas, chipping sparrow abundance increased. In her research, Schmiegelow (1995) also assessed the importance of mixed stands to the observed abundance of avian species. From this work she discovered that least flycatcher *(Empidonax minimus)*, red-eyed vireo, American redstart, mourning warbler, black-throated green warbler, warbling vireo

(Vireo gilvus) and rose-breasted grosbeak *(Pheucticus ludovicansus)* were found with significantly greater frequency in deciduous dominated stands with a small coniferous component (10-20 %).

In addition to the species found by Schmiegelow to prefer old aspen forest, the Aspen Biodiversity Project (Anonymous 1994) also placed downy woodpecker *(Picoides pubescens),* white-breasted nuthatch *(Sitta carolinensis),* hairy woodpecker *(Picoides vilosus),* Swainson's thrush *(Catharus ustulatus),* Canada warbler *(Wilsonia canadensis),* magnolia warbler *(Dendroica magnolia),* brown creeper *(Certhia americana)* and pileated woodpecker *(Dryocopus pileatus)* in the same category. Campbell *et al.* (1990) reported that downy woodpecker, white-breasted nuthatch and warbling vireo prefer to nest and forage in deciduous forest. However, they do note that downy woodpecker has been observed to nest in burned forest areas. Keisker's (1987) results support this, as she demonstrated downy's preference for dead trees with live tops. Darling and Farr (1994) reported dramatic declines in least flycatcher, Swainson's thrush, warbling vireo, red-eyed vireo and Philadelphia vireo (*vireo Philadelphia)* in their one site of clear-cut aspen forest. They did not however, encounter Canada or magnolia warblers in their field work. Westworth and Telfer (1993) reported the greatest densities of breeding least flycatcher, rose-breasted grosbeak and warbling vireo in 14 year old aspen forest. Yahner (1991) reported red-eyed vireo only nested in mature stands of aspen in central Pennsylvania.

Siddle (1991) recorded 35 sightings of Canada warbler and 45 sightings of magnolia warbler in the Peace River lowlands. However, he mentions the Canada warbler has been classed as a sporadic breeder in the Hudson Hope area along the south side of the Peace River. There have been no reported sightings in the Williston Lake watershed, but it's occurrence is possible. He does not describe the distribution of magnolia warbler.

Campbell *et al.* (1990) note that the pileated woodpecker and northern flicker *(Colaptes auratus)* have demonstrated a preference for nesting in deciduous trees (70% and 48% respectively), and that pileated woodpeckers have an affinity for trembling aspen in particular (32% of nest observations). Keisker (1987) demonstrated that pileated woodpeckers used trees above 30 cm dbh, but, clearly preferred trees over 40 cm dbh. Nest detections were also greatest in large aspens with scars and fungal conks present. However, unlike 5. *varius,* who prefer live trees, pileated woodpeckers preferred dead or dead trees with live top (Keisker 1987). Pileated woodpeckers forage in many different forest types (Bull and Holthausen 1993). However, the breeding territory required by a pair of pileated woodpeckers has been found to be in the range of 407 - 597 ha in northeastern Oregon (Bull and Holthausen 1993). Therefore, studies attempting to quantify their density, distribution and habitat requirements would necessitate a labour and cost intensive sampling program.

The Alberta Biodiversity Project reported that the northern flicker was detected with the greatest frequency in old and young stands where snag and downed woody debris density was greatest. Mature stands displayed the lowest detection frequency of flickers and also contained the lowest

density of snags and downed woody debris. Westworth and Telfer (1993) reported a density of 5.7 breeding pairs of northern flicker, but noted that they were limited to 14 yr old forest that was established by fire. Keisker (1987) reported flickers preferred to nest in dead or rotted live trees and used all trees species available. Flack (1976) demonstrated that the use of aspen forest by northern flicker depended on the availability of snags with a dbh of at least 15 cm. Therefore, the northern flicker may benefit initially from fire, as snags are created, however, once the majority of the snags have fallen and only large healthy trees remain (mature forest), nesting sites may become scarce.

Philadelphia vireo, black-throated green warbler and Canada warbler are listed as species vulnerable to extirpation from its range in B.C. by the B.C. MoELP, Wildlife Section (B.C. MoELP 1995). Askins and Philbrick (1987) also isolated black-throated green warbler, American redstart and Canada warbler as long-distance migration species that have demonstrated a decline in abundance since 1953 in eastern Hemlock forest, Connecticut, USA. As mentioned earlier, Philadelphia vireo were prolific in undisturbed aspen forests sampled in the Dawson Creek Forest District by Darling and Farr (1994). However, Philadelphia vireo was absent from the one site that was disturbed by clear-cut logging. Therefore, species that have demonstrated a reduction in population or are sensitive to habitat disturbance but, have not exhibited exclusive use of aspen dominated forest, were elevated to the moderate sensitivity rank.

2.2.2 Small Mammals

The available information on the response of small mammals to aspen forest disturbance is scant. Most information collected on small mammal response to forest disturbance has focused on coniferous forest types. However, Kirkland (1977) described small mammal response to deciduous forest clear-cutting in West Virginia and concluded that, in general, small mammal densities increased following disturbance (eg. 40.95 ind/ha in old forest; 103.49 ind./ha clear-cut). He also did not find any species that existed exclusively in old forest (Kirkland 1977). From discussions with others who are currently, or have previously worked in this field it is emphasized that no species have been found to rely exclusively on old forests (Dale Seip, MoF Prince George; Brad Stelfox, Alberta Environmental Center). Their opinion is that there may be a reduction in trap captures following clear-cutting of some species, but, populations have eventually recovered shortly after the reestablishment of vegetation cover. Landres *et al.* (1988) caution the use of small mammals as indicator species. They indicate that annual and seasonal fluctuations in populations can obscure the effects of the researchers treatments, thereby limiting their usefulness as a reliable indicator group. However, should the PCWP choose to examine trends in small mammal response to aspen forest disturbance, the following species have been observed to respond to forest disturbance.

In the Prince George Forest District, Seip (unpublished data), found greater densities of red-backed voles *(Clethrionomys gapperi)* and masked shrew *(Sorex cinereus)* in old coniferous

forest when compared to younger forest, whilst, the frequency of capture of meadow vole *(Microtus pennsylvanicus)*, deer mice *(Peromyscus maniculatus)* and dusky shrew *(S. monticolus)* increased in clear-cut stands. However, only the red-backed vole appeared to show any significant declines in capture rates. Darling and Farr (1994) however, did not find any declines in any small mammals, including red-backed voles following clear-cutting of aspen forest in Forest District - 47. Rather, they reported an increase in the frequency of deer mice trapped (Darling and Farr 1994).

The Alberta Biodiversity Project reported greater captures ($p < 0.005$) of red-backed vole, meadow vole and masked shrew in old forest compared to mature and young aspen stands. Northern flying squirrel *(Glaucomys sabrinus)* demonstrated an affinity for nesting in large aspen snags (> 21 cm dbh). The number of captures was greatest in old (n=7) and young stands (n=3) where snags were most available (Anonymous 1994). Bat activity was also found to be greatest in old stands when compared to mature and young stands. *Myotis spp.* constituted the greatest Taxonomic group observed followed by the hoary bat *(Lasionycteris noctivagans)*. There are no known studies that document bat response to aspen forest disturbance in B.C.

The effects of aspen forest disturbance on small mammals remains unclear in B.C. More research on this aspect of wildlife response to fire would undoubtedly prove useful. However, no one species of small mammal has been shown to rely exclusively on older aspen forest stands.

2.2.3 Herptofauna

The response of herptiles to disturbance of aspen forest is relatively unstudied. In their review of the effects of the burning program within the Peace District, Backmeyer *et al.* (1992) discuss the fact that amphibian and reptile habitat in the Peace District are found primarily in wetland habitats. Therefore, they are likely impervious to the effects of fire. They do note however, that due to the terrestrial nature of wood frogs *(Rana sylvatica)* that they may be susceptible to negative impacts associated with fire. Linda Dupuis (pers, comm, U.B.C. Center for Conservation) agrees with this statement and added that boreal toad *(Bufo boreas)* would also be susceptible for the reasons similar to that of the wood frog.

2.3 Summary

Removal of the dominant overstory by prescribed burning will likely result in the loss of large live trees and the associated high deciduous canopy. Although snags may be created by fire, the duration of their availability will diminish over time (20-40 years; Anonymous 1994). Therefore, both primary and secondary cavity nesting species will suffer immediate and delayed effects respectively, of habitat loss as a result of fire. Species that require large trees to

excavate cavities (eg. pileated woodpecker) or occupy cavities for nests will incur a reduction in suitable habitat (Keisker 1987). Avian species have been the only species that have a well documented response to mature aspen forest disturbance. Therefore, the monitoring program present herein will focus on the species identified above (Table 1).

3.0 MONITORING PROGRAM DESCRIPTION

As detailed in the Terms of Contract, a monitoring program is presented that has been designed to evaluate the following:

- observed decline in selected piciforme and passeriforme wildlife species (Table 1) following disturbance of mature and old aspen forest by prescribed burning;
- intensity and duration of selected wildlife species response to upland prescribed burning of mature and old aspen dominated forests;
- observed preference of identified wildlife species to mature aspen stands for a critical portion of their life history (nesting and/or foraging) and;
- major habitat features (eg. tree basal area; snags/ha) responsible for observed response in wildlife species.

3.1 Long-Term Wildlife Community Response to Prescribed Burning of Upland Mature Aspen Forest

The most rigorous long-term studies concerned with the description of ecosystem response and development following disturbance are based on the monitoring of communities or populations at permanent sample plots that are sampled at regular intervals over many years (eg. Swank and Crossley 1988, Edmonds 1982, Bormann and Likens 1979). However, the logistics, personnel and expense required to organize these types of projects limits the ability of many researchers to undertake them. As a result, many scientists have chosen the space-for-time substitution method as an alternative method (Pickett 1989). Space-for-time substitution involves sampling separate areas of the same landscape unit of different age classes since disturbance (i.e. 1 yr, 10 yr, 50 yr, 100 yr). In doing so, the long-term development of a forest type and its use by wildlife communities can be approximated. When rigorous methods are applied, quantitative models that permit prediction of habitat or community parameters are possible. This method has been successfully applied by others (eg. Westworth and Telfer 1993, Thompson and Capen 1988, Anonymous 1994).

Implementation of a space-for-time study design for the purpose of reconstructing the development of aspen forests following burning in the PCWP study area would achieve the following goals:

- document the intensity of changes in the wildlife community or selected species (eg. *S. varius)* resulting from the prescribed burning of mature and old aspen forests in the Peace/Williston watershed, as well as, providing an evaluation of other studies that observed and predicted the magnitude of changes in the wildlife community following removal of mature and old aspen forest;
- provide an indication of the duration of negative impact of prescribed burning on the pre-existing wildlife community or selected species; and
- provide an indication of the key forest habitat features required by selected species.

3.1.1 Experimental Design

Twelve stands consisting of three replicates of four seral stages or age classes would be selected for study. This design provides adequate fidelity to determine changes in wildlife community or selected species among different forest age classes, while not compromising statistical rigour. The number of ages classes and replicates required was established from evaluation of power analysis completed by Schmiegelow and Hannon (1993) and the experimental design used in Aspen Biodiversity Project (Anonymous 1994). A discussion of the implications of varying the sample size and replicates follows in section 4.1.

3.1.2 Site Selection

Stand Age Class: An equal number of stands from different forest age classes should be selected. Age classes include: recently disturbed (0-10 yr since disturbance); early aggrading (15-40 yr since disturbance); late aggrading or mature (50 - 70 yr since disturbance); and, over mature forests (80 yrs or more since disturbance). The age classes suggested would provide reasonable fidelity in determining the duration of the effects of prescribed burning on selected wildlife species. Confirmation of stand age as determined from increment cores should be conducted upon selection.

Stand Location: Under optimal conditions, study sites for all age classes would be evenly distributed throughout the Williston watershed. Sites should be either established in one forest biogeoclimatic zone. If two zones are required, then establish equal numbers of sites per age

class in each zone. Where possible, care should be taken to avoid the selection of sites that produces a grouping of age class sites into individual areas. Adherence to this will limit the potential for spatial autocorrelation (see Section 4.4). However, due to limits in access, uniform distribution of sites throughout the Williston watershed may not be feasible. Under these conditions sites may be established within an accessible region and results extrapolated for the remainder of the watershed.

Stand Size: Stands of equal size with similar topography, aspect and intensity of disturbance (hot/cool burns or clear/partial cutting) should also be selected. Stand size is an important consideration. Johns (1993) and Schmiegelow (1995) have demonstrated avian communities in aspen forests can be influenced by stand size. In his study of the variation in avian community assemblages among stands that ranged in size from 0.1 ha to 36 ha, Johns (1993) reported a forest interior community occurred at 34 ha, whereas smaller stands more closely resembled edge communities. Schmiegelow (1995) plotted the accumulation of interior forest bird species against forest area sampled and demonstrated that the greatest number of forest bird species (n=50) were detected when sampling covered 300 ha. Schmiegelow's curve of species accumulation was nearly linear to 100 ha (n=36) and levelled off at approximately 100 ha (n=42). Therefore, to minimize the opportunity of missing some forest bird species, a minimum stand size of 100 ha should be adopted. Adherence to this criteria will ensure that observed differences in avian community are due to the designed criteria (i.e. variation in forest age or forest composition), and not stand size.

3.1.3 Avifauna Studies

A combination of avian community census techniques are required to achieve the study goals described in Section 3.0.

Point-Count Census: The point-count method has been adopted as the recommended standard for research dealing with observations or the creation of models that predict avian community response to habitat alteration (Ralph *et al.* 1993; Thompson *et al.* 1993). As a result, its application is widely distributed among other researchers, permitting comparisons among studies. As summarized in Table 2, point-counts provide an index of species abundance, habitat specificity of the avian community, an adequate estimate of rare species occurrence, as well as, characterize bird use in all habitat types and provide density estimates. In addition to the latter benefits, the cost per data point is low. A significant amount of potential measurement error exists when employing point count methods, as a result, a high level of sampler competency is required. To reduce the amount of potential measurement error, field technicians should be exposed to training sessions aimed at standardizing methodologies prior to data collection (Ralph *et al.* 1992).

Table 2: Census and demographic monitoring methods.

Variables and characters	Census			Demographic	
	Point count	Spot map	Area search	Mist nets	Nest search
Variables measured					
Index to abundance	yes	yes	yes	yes	partly
Density	no	yes	no	no	partly
Survivorship (adult)	no	no	no	yes	no
Survivorship (juvenile)	no	no	no	yes	partly
Productivity	no	no	no	yes	yes
Recruitment	no	no	no	yes	no
Habitat relations	yes	yes	yes	little	partly
Clutch size	no	no	no	no	yes
Predation/parasitism	no	no	no	no	yes
Individuals identified	no	no	no	yes	yes
Breeding status known	no	yes	no	partly	yes
General characters					
Habitat types measured	all	some	most	some	few
Habitat specificity	good	good	good	fair	good
Rare species measured	many	few	many	some	few
Canopy species measured	all	all	all	some	few
Area sampled known	partly	yes	yes	partly	yes
Size of area sampled	moderate	small	small	large	small
Training necessary	much	much	moderate	much	much
Observed error potential	high	high	moderate	moderate	moderate
Use in non-breeding	yes	no	yes	yes	no
Cost per data point	low	high	low	high	very high
Applicable scale	broad	local	broad	broad	local

reproduced from: Ralph et al. (1992)

Point-count bird census should be conducted to achieve an estimate of avian bird community abundance. Avian bird counts would be estimated within 100 m radius points using avian vocalizations as the primary identification feature. Visual observations typically comprise a secondary measure of identification. Incidence of bird identification beyond the 100 m radius

should also be recorded, but marked as being outside of the plot. Each point should be censused a minimum of four times for ten minutes each, between dawn and 1000 hrs. To increase sample size, or reduce the time required for sampling, point census sampling period may be reduced from ten to five minutes without significantly compromising results (Schmiegelow, pers. comm). Point visits should be conducted between May 10 - July 5 and limited to days free of rain and high winds. An effort should be made to vary the time of site visits. For example, site A should not be repeatedly sampled at 0500 each visit, while site B was always sampled at 0900. Avoidance of this practice would aid in minimizing the amount of potential temporal bias (i.e. see Section 5.0 re. temporal autocorrelation). Census methods have been selected based on recommendations suggested by Ralph et al. (1992).

Point Selection: A minimum of eight points would be established for each stand covering 25.16 ha. Considering three stands in each of four age classes would be sampled, a total of 301.92 ha would be covered for each completed survey. As Schmiegelow (1995) demonstrated, the maximum number of forest bird species were encountered when 250-to-300 ha of forest area was sampled. Sampling eight points would therefore ensure that an attempt has been made to capture data on all available species. In addition, completion of eight sample points per stand would be greater than the Aspen Biodiversity Project by two points per stand. This project had noted that an inadequate number of rare species were encountered during their field sampling to include them in the analysis.

Points should not be established within 100 m from the stand boundary and may be selected randomly if forest vegetation composition, topography and aspect are uniform; located along a grid of transect lines to form a contiguous block; or systematically stratified based on known site conditions (i.e. hilltops, valleys, slopes). Selection of the latter criteria will ultimately depend on the nature of the stands selected and the ability of the field crew to sample stands within the allotted time period. However, plots located in a contiguous block along a grid will likely be the most time efficient means of sampling the avian community.

Cavity Nest Search: In addition to the point-count method, a cavity nest search should be conducted. Collection of this data will be useful in determining the density of breeding cavity nesting birds (esp. *S. varius)* and availability of suitable cavities for secondary cavity nesters. This information would not be provided by simply conducting point counts. Data describing number and dimensions of available cavities; whether the cavity is used or unused; species using cavity; host tree characteristics (dbh, height class, condition), and used cavity dimension and azimuth orientation should be collected within each of the 100 m radius point count plots. Tree cavity searches may be conducted following completion of all point counts for the day of sampling, as begging calls from young and identification of adults recorded during the point-count census will aid in locating nesting pairs. Cavity nest search techniques should be similar to those described by Keisker (1987).

Habitat Description: The goal of the habitat description should be to relate observed changes in avian species or community response to changes in vegetation. Ralph *et al.* (1992) describe in detail two methods of habitat assessment; 1) broad habitat classification; and 2) estimation of stand characteristics. The type of habitat description adopted by the researcher is therefore contingent upon the goals of the study and ultimately budgetary constraints. Provided with the option of limited resources, the broad habitat classification may be conducted. However, Ralph *et al.* (1992) clearly state that this method provides the minimum information necessary to describe vegetation habitat and that correlative analysis between habitat and avian communities is not possible. As a result, they recommend that other habitat description techniques be employed where possible.

Broad Habitat Classification method provides a coarse description of vegetation communities present within each sample point. A map or diagram of each census point would be generated to delineate areas dominated by habitat type (eg. forest, brush, marsh). Ground cover (herbaceous), shrub and tree species comprising greater than 10 percent of the study plot would be listed and ranked according to their relative abundance. The approximated average height of the canopy or shrub layer would also be recorded to the nearest meter. Wet areas including water depth, and area would also be recorded.

Estimation of Stand Characteristics method would provide enough data to determine the vegetation formation, association, and major structural characteristics. Data collected would be suitable for correlative analysis. Procedures are detailed in Ralph *et al.* (1992). In short, a 30 m radius sub-plot, centered on each census point would have the following information collected. Estimate of percent vegetation cover per species; estimate canopy height and various sub-layers; and, dominant species within the canopy would be recorded. The d.b.h. and species of the largest and smallest trees, as well as, all visible snags would be recorded to the nearest centimetre. Cover and cover abundance values, vegetation species comprising at least 10 percent of total cover, number and dimensions of logs present should also be recorded.

3.1.4 Small Mammal Studies

The occurrence of small mammals including the red-backed vole and the masked shrew may be evaluated by setting up to 15 sherman live traps within each point count area. By setting 15 traps per point, over 120 trap nights may be obtained for the entire stand given eight points per stand.

Cavity nest searches should also include records of occurrences of northern tree squirrels. Recording the occurrence of flying squirrels will not take any additional time, however, setting and retrieving live traps would, therefore its priority should be evaluated by the PWCP.

3.2 Differences in Wildlife Community Composition Along a Deciduous-Coniferous Forest Gradient

To evaluate the exclusive use of wildlife communities in deciduous aspen forest, a gradient of forest types ranging from deciduous (aspen) dominated (< 10% conifer composition), mixed deciduous-coniferous (40% - 60%), and coniferous dominated forests (< 10% deciduous composition) should be sampled. Composition of forest stands should be verified through either aerial photography, or through ground truthing.

Similar experimental design and methods for wildlife community sampling and site selection should be followed in this study as those described in Section 3.1. Exceptions to the design exist in the selection of three forest types (conifer-mixed-deciduous), with four replicate stands of each; as opposed to four stands and three replicate stands. In addition, stands selected should be mature or old stands. Should they meet the criteria for percent composition of coniferous/deciduous forest, old or late aggrading aspen stands selected in the *aspen age-class study* (Section 3.1) may be used as deciduous dominated stands in this study.

4.0 Statistical Analysis

To achieve the goals of the work plan and support the results with quantitative results, the following regimen of statistical analysis is suggested. At the minimum, the analysis of variance should be completed. MANOVA and Mantel's test will enhance the ability of the researcher to quantitatively describe and present the relationships between species and habitat. However, this protocol may be considered by some to be in excess of what is required. However, this for the PWCP to decide. If followed, the program provided below will supply defendable results.

4.1 Power Analysis

Experimental data are invariably subject to random error, hence, there is some uncertainty about any decision to reject or retain a null hypothesis on the basis of a statistical test (Nemec 1991). Potential errors in this assessment are categorized as being either a Type I or Type II error. The rejection of a true null hypothesis is called a Type I error, whereas, the acceptance of a null hypothesis when it is in fact false is defined as a Type II error (Sokal and Rohlf 1973). Type I error is routinely evaluated by calculating a p value or by quoting the significance level (*i.e.* $a = 0.05$). However, evaluation of the probability of committing a type II error is seldom addressed by researchers. Clearly, from a managers perspective, committing a Type II error would have serious ramifications to the success of an adopted treatment policy. The probability of committing a Type II error can be evaluated through the use and understanding of the power of the test.

Nemec (1991) provides this description of power:

> "The power of a statistical test is the probability that, when the null hypothesis is false, the test will reject that hypothesis. A powerful test is one that has a high success rate in detecting even small departures from the null hypothesis. In general, the power of a test depends on the adopted level of significance, the inherent variability of the data, the degree to which the true state of nature departs from the null hypothesis, and the sample size. Computation of this probability for one or more combinations of these factors is referred to as a power analysis."

Avoidance of Type I error can be evaluated *post hoc* by comparing the calculated *P* values against the established alpha (eg. 95 % C.I. or $a = 0.05$). This is usually sufficient in evaluating whether an actual difference occurs among variables. The probability of committing a type II error can also be evaluated *post hoc*. However, this is cautioned against, for if it is determined that the power was inadequate, it is usually too difficult to repeat the experiment to remedy the problem. Therefore an *a priori* evaluation of power is recommended. This was completed by Schmiegelow and Hannon (1993) for their study on the effects of forest fragmentation on boreal birds. Based on variances collected from the literature describing similar types of data *(i.e.* no. bird species/ha), they determined that to detect a 20% reduction in bird species abundance, a sample size of 12 was required. Therefore, they adopted a design that incorporated three replicates of four fragmented forest sizes (n = 12). The Aspen Biodiversity Project that was interested in a reduction in the number birds among forest age classes also incorporated a sample size of 12, with four replicate stands over three age class groups into their experimental design. The experimental design suggested in the work plan herein, follows the power analysis recommended by Schmiegelow and Hannon (1993) and the experimental design of the Aspen Biodiversity Project. Differences exist between this work plan (n=4) and the Aspen Biodiversity Project (n=3) in the number of forest age classes. However, the increase in the number of points per stand from 6-to-8, compensates for this difference, which results in both study designs having 24 points per age class. Therefore, the same statistical power exists for this study as the Aspen Biodivesity Project, with the exception that of more points are sampled, thereby increasing the potential for detecting avian species.

Variations in Sampling Intensity: Reduction in replicate size by one (eg. from three to two per age class using Section 3.1 as an example) would result in an increased probability of committing a Type II error, and would likely decrease the ability to detect a change in population abundance. However, this level of detection may still be adequate depending on the amount of parameter variation encountered within replicate samples. If an increased level of detection is required (i.e greater than 20%), Schmiegelow and Hannon (1993) suggest that the number of replicates should increase by one replicate to four per age class (group).

Studies attempting to describe plant or forest communities have ranged from sampling 1 - 20 % of the area in question (P. A. Quinby pers comm.).- The Alberta Biodiversity Project sampled on average 10 percent of stand area, with a mean stand size of 174 ha (Anonymous 1994). Schmiegelow (1995) sampled up to 45 percent of her 100 ha stands, but this level of detail is required to achieve her study objectives, which are separate from those described in this work plan. Clearly, for the study proposed herein, variables of stand size, accessibility and cost play an important role in determining the number of points selected. Sampling eight points in a 300 ha stand would accomplish approximately 10 percent of the area sampled. Clearly if the mean stand size is less than 300 ha sampling intensity would be greater than the Aspen Biodiversity Project and would therefore increase the likelihood of detecting increased levels of rare species. However, should stand size be greater than 300 ha in size, an increase in the number of census points should be established to sample a minimum of 10 percent of stand area.

The likelihood of this program resulting in too few detections of rare species for meaningful statistical analysis is a possibility. For example, the Aspen Biodiversity project determined that species that recorded fewer than seven observations, even if they occurred in one group, would not be included in the analysis for they would not show statistical significance. Strategies can be employed to overcome this problem. (1) increase sampling intensity to include more point count stations, thereby sampling a greater proportion of stand area and increasing the opportunity of species detection; (2) use modified transect sampling enroute between census point stations to increase the probability of encountering rare species; and (3) reduce sampling time per point count station to decrease the amount of time spent at a station in an effort to increase the number of stations visited. Schmiegelow 1995 reduced the point-count sample interval from the standard ten minutes to five minutes in her efforts to sample a greater proportion of the stand area without compromising her ability .o detect changes in avian community among treatments.

4.2 Analysis of Variance

A one-way analysis of variance (ANOVA) would be used to test the null hypothesis that no differences exist among forest age classes using wildlife (avian) community parameters ($P > 0.05$; Table 3). Data may be log-transformed (eg. $\log_{10}$ or $\log_{10}[x + 0.1]$) to more closely approximate the assumptions of linearity, normality and homogeneity of variance required for non-parameteric ANOVA (Green 1979).

A one-way multivariate analysis of variance (MANOVA) could then be used to test the null hypothesis that no difference exists among forest age class using the wildlife abundance and breeding density parameters and associated habitat variables (Table 3). MANOVA illustrates which variables (bird species) contribute significant results for the hypothesis of no differences among forest age class. This is done with a plot of canonical variate 2 (CV2) versus canonical variate 1 (CV1), which is generated by MANOVA, and would be used to graphically illustrate differences among age class variables (bird species), as well as those variables contributing most

to group separation. Only CV1 should be interpreted because it is the only axis that is truly significant in a statistical sense (Gray *et al.* 1988). Wilks' Lambda, which is a multivariate F-statistic, would be used to assess the MANOVA results, as outlined by Harris (1975).

If the assumptions of analysis of variance cannot be met following transformations, the Kruskal-Wallis nonparametric test may be used instead. Schefler (1979) notes that the Kruskal-Wallis test is especially useful for analyzing data that involve more than two treatments. He also states that the test rapidly loses power as the treatment *n*-numbers decrease down to five or less per treatment. Therefore, individual point count stations (n = 24 x 4) should be used in this test rather than an average for each stand (n = 3 x 4).

Table 3: Summary of statistical procedures and transformations for parameters.

Test	Transformation (if necessary)	Parameter Group	Parameter Unit
one-way ANOVA (among four disturbance classes)	$\log(x+1)$	Wildlife species	abundance taxonomic richness breeding pairs
	$\log(x+1)$	Habitat Parameter	cavity density tree size snags density
one-way MANOVA (among four disturbance groups)	$\log(x+1)$	Wildlife species	abundance taxonomic richness breeding pairs
	$\log(x+1)$	Habitat Parameter	cavity density tree size snag density
Mantel's Test (correlation between habitat and wildlife)		Wildlife species	MANOVA site scores for abundance and breeding pairs
		Habitat	MANOVA site scores for cavity density; tree size; snag density

4.3 Mantel's Test

The NTSYS (Rohlf 1990) software program may be used to run Mantel's test (Mantel and Valand 1970) testing the hypothesis that there is no significant correlation between inter-site distance matrices constructed from community (eg. cavity nesters) and habitat variables (eg. host tree size). Mantel's test is also valuable when quantifying the amount of spatial and temporal autocorrelation present within the data.

Mantel's test assesses the degree of association, concordance or correlation between two distance matrices calculated for the same set of *n* sites. Euclidean distances would be calculated for each data set using mean values. The similarity between two distance matrices is expressed as an *r* correlation (or association) value, which is analogous to a bivariate r^2 value from a regression analysis (Keith Somers, unpubl. data). The significance of the matrix correlation is assessed through a process of randomization. One of the two data matrices is randomly rearranged and the associated *r* statistic is recalculated. Correlations based on one thousand permutated matrices would be calculated to generate an expected distribution when one matrix is truly random. The resultant "expected" distribution is analogous to other statistical distributions but does not require that the data meet assumptions characteristic of parametric statistical procedures that are rarely met by ecological data (Jackson 1988, Legendre and Fortin 1989).

Before evaluating the significance of the matrix correlation following the Mantel test, the Bonferroni correction technique must be applied to correct for multiple comparisons (Cooper 1968, Miller 1977). This correction takes into account the fact that several tests (v) are done at the same time for a given overall significance level (x) (Legendre & Fortin 1989). The Bonferroni correction thereby produces an adjusted *p* value that reduces the chance of committing a Type I error and produces a more powerful result (Harris 1975). The correction is obtained by dividing the token significance level (x) by the number of tests completed (x/v = Bonferroni correction). For example, if a significance level of 0.05 is desired, then 0.05 is divided by the number of comparisons using the Mantel test (e.g. 0.05/5 tests equals a critical P value of 0.01 to maintain an overall *P* value of 0.05).

The results of the Mantel's test are summarized and presented in a correlation matrix describing relationships between the various matrices of parameters. However, because this results in a correlation matrix there may be difficulties in interpreting the various correlations. To overcome this limitation, the correlation matrix may be projected using Principal Co-Ordinates Analysis (PCoA) to display the relative proximity of the various community and habitat matrices (Gower 1966). PCoA ordinates the correlations in a two-dimensional plane (X-Y plot), thus indicating which variables are related or unrelated. This is expressed in the plot as those parameters that are situated close to one another are similar, and those that are not similar are situated far apart.

4.4 Autocorrelation

Ecosystems are structured in both time and space, either by environmental forces or by biological activity and/or species life history. The result is a patchy spatial distribution, or biologically active periods for species, populations or communities. The departure of ecological systems from random or uniform distributions creates autocorrelation. A variable is said to be autocorrelated (or regionalized) when it is possible to predict the values of this variable at some point in space (or time) from the known values at other sampling points, whose spatial (or temporal) positions are also known (Legendre & Fortin 1989). Traditional statistical tests assume that samples are independently drawn from a population. If autocorrelation exists, samples are not independent and hence, statistical tests are biased. Generally such tests are too liberal, providing significance too often. Spatial and temporal autocorrelation can be evaluated using the Mantel test (Legendre and Fortin 1989, Jackson 1988, Sokal 1979). Spatial and temporal distance matrices are calculated based on actual straight-line distance between sites and the difference in time between sampling each site. The use of these spatial and temporal matrices is described below.

Spatial Autocorrelation: Universal Transverse-Mercator (UTM) East and North coordinates determined from sample locations within the study area on 1:50000 topographic maps sheets can be compared among forest classes using one-way ANOVA. Euclidean distances between sites, using the UTM coordinates, would be determined and compared for concordance with the other matrices using Mantel's test.

Temporal Autocorrelation: Temporal autocorrelation would be assessed for each site based on the mean date and time when each stand was visited. This test will aid in determining if bird communities observed could be predicted or were biased based on the dates or time of day when the samples were collected. To determine short-term temporal influences, sites would be numbered according to the date that samples were collected and would then be compared using the same procedure described for spatial autocorrelation.

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6.0 Cost Estimate

6.1 Differences in Wildlife Community Composition Among Four Age-Classes of Aspen Forest

To complete this work it would require one crew of two persons. Morning bird counts would occur between dawn and 10:00 am daily. A nest search and habitat description would be required for each study plot, however, unlike the point-count census, nest search and habitat description would only be completed once. Nest searches could be completed following morning census. Habitat descriptions could be completed following completion of morning bird counts and nest searches, or on days when whether conditions are unsuitable for bird census. Habitat descriptions will likely require additional time to complete.

Bird Census Point Count:

Four study areas and 3 timber stands per study area: 12 total study sites

8 points per study site: 96 total study points for a complete survey

4 visits per study point

10 Minute Point-Count Survey:
8 points x 30 minutes each (10 minutes surveying, 20 minutes in transit between points) = 4 hours

8 points/person/day
2 people = 16 points/day
Days to do 1 complete survey = 96/16 = 6 days
4 surveys x 6 days/survey = 24 days to complete bird census

5 Minute Point-Count Survey:
10 points x 25 minutes each (5 minutes surveying, 20 minutes in transit between points) = 4.2 hours

10 points/person/day
2 people = 20 points/day
Days to do 1 complete survey = 96/20 = 4.8 days
4 surveys x 4.8 days/survey = 19.2 days to complete work

Cost Estimate: Point Establishment, Point Counts, Nest Search and Habitat Description

10 Minute Point-Count Survey:

	Project Biologist		Project Technician	
	No. of Days	$ Cost	No. of Days	$ Cost
Travel	2.0	600	2.0	500
Point Establishment	8.0	2 800	8.0	2000
Point Counts	24	8 400	24	6000
Habitat Description	6	2 100	6	1 500
Total	40	13 900	40	10 000

5 Minute Point-Count Survey:

	Project Biologist		Project Technician	
	No. of Days	$ Cost	No. of Days	$ Cost
Travel	2.0	600	2.0	500
Point Establishment	8.0	2 800	8.0	2 000
Point Counts	19.2	6 720	19.2	4 800
Habitat Description	6	2 100	6	1 500
Total	35.2	12 200	35.2	8 800

6.2 Differences in Wildlife Community Composition Along a Deciduous-Coniferous Forest Gradient

To complete the program as described in Sections 3.1 and 3.2 would include an additional crew of two persons. Morning bird counts would occur between dawn and 10:00 am daily. A nest search and habitat description of each of the study areas would occur daily after the morning census. Traps would set in the late evening and checked after morning bird counts. The breakdown of work would be as follows:

In an order to maximize the efficiency of the data collection, if the mature or late aggrading aspen dominated stands have less than 10 % coniferous component in their overstory, they may be used as the deciduous stands in this study.

Estimates of effort and person/days for this program are described below:

Three study areas and 4 timber stands per study area: 8 total study sites
(4 stands completed in aspen age class study)

8 points per study site: 64 total study points for a complete survey

4 visits per study point

10 Minute Point-Count Survey:
8 points x 30 minutes each (10 minutes surveying, 20 minutes in transit between points) = 4 hours

8 points/person/day
2 people = 16 points/day
Days to do 1 complete survey = 64/16 = 4 days
4 surveys x 4 days/survey = 16 days to complete bird census

5 Minute Point-Count Survey:
10 points x 25 minutes each (5 minutes surveying, 20 minutes in transit between points) = 4.2 hours

10 points/person/day
2 people = 20 points/day
Days to do 1 complete survey = 64/20 = 3.2 days
4 surveys x 3.2 days/survey = 12.8 days to complete work

Cost Estimate: Point Establishment, Point Counts, Nest Search and Habitat Description

10 Minute Point-Count Survey:

	Project Biologist		Project Technician	
	No. of Days	$ Cost	No. of Days	$ Cost
Travel	2.0	600	2.0	500
Point Establishment	6.0	2 100	6.0	1 500
Point Counts	16	5 600	16	4000
Habitat Description	4	1 400	4	1000
Total	28	9 700	28	7000

Study Total: $ 16 700

5 Minute Point-Count Survey:

	Project Biologist		Project Technician	
	No. of Days	$ Cost	No. of Days	$ Cost
Travel	2.0	600	2.0	500
Point Establishment	6.0	2 100	6.0	1 500
Point Counts	12.8	4 480	12.8	3 200
Habitat Description	4	1 400	4	1 000
Total	24.8	8 580	24.8	6 200

Study Total: $ 14 700

6.3 Project Cost Summary

Aspen forest Age Class Study

10 Minute Point Sampling:	$23 900
5 Minute Point Sampling:	$21 000

Deciduous - Coniferous Forest Study

10 Minute Point Sampling:	$16 700
5 Minute Point Sampling:	$14 700

Total Study Cost

10 Minute Point Sampling:	$40 600
5 Minute Point Sampling:	$35 700